EXTENDED SCWO PILOT TESTING OF CHEMICAL MUNITION WASTES

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The U.S. Army's Assembled Chemical Weapons Assessment (ACWA) Program is seeking technology alternatives to incineration for the disposal of chemical weapons. General Atomics (GA) has proposed a complete, non-incineration technical solution for demilitarization of all types of assembled chemical weapons. The GA Total Solution (GATS) process is based on mechanical disassembly and separation of energetic components, agent access by munition cryofracture, agent hydrolysis and neutralization, and destruction by supercritical water oxidation (SCWO).

Demonstration testing of the GATS unit operations was conducted in early 1999. Favorable results of this validation testing led to initiation of extended pilot testing referred to as Engineering Design Studies (EDS). The primary goals of the EDS testing are to demonstrate long-term operability, suitable materials of construction, and reliable transport of salts through the system. Data generated by EDS will support development of full-scale plant designs for the Pueblo Chemical Depot at Pueblo, Colorado and the Blue Grass Chemical Activity near Lexington, Kentucky.

The EDS testing is comprised of four 500-hr campaigns, processing the following waste streams:

1. HD hydrolysate/simulant – High chloride and sulfate, salt generation rate of 10 lb/hr.

2. Tetrytol hydrolysate/Dunnage – Thick slurry feed, salt generation rate of 1 lb/hr.

3. Cyclotol hydrolysate/M28 hydrolysate/Aluminum hydroxide/Dunnage - Thin slurry feed, high organic nitrogen content, salt generation rate of 13 lb/hr.

4. GB hydrolysate/simulant - High fluoride and phosphate, salt generation rate of 7 lb/hr

The first three 500-hr tests have been completed with outstanding organic destruction. Total organic carbon in the liquid effluent has been near or below the detection limit of 1 ppm. In the gaseous effluent carbon monoxide has been less than 10 ppm and the dioxin/furan levels have bettered the US EPA Maximum Achievable Control Technology (MACT) standards by a factor of more than 200. For the high nitrogen energetics hydrolysate streams, NO_x has been less than the detection limit of 2 ppm. High system availabilities were achieved during the 500-hr tests, ranging from 66 to 84%.

Results from the EDS testing have provided key inputs to design of the full-scale plants. For example, the high availabilities attained readily support the required full-scale plant availability of 39%. A preliminary design package was completed for Pueblo Chemical Depot in January 2001 and a similar package for the Blue Grass Chemical Activity is currently in review.

Engineering Design Studies on Supercritical Water Oxidation of Assembled Chemical Weapons Wastes

M.H. Spritzer and G.T.Hong

SCWO Workshop on Achievements and Challenges in Commercial Applications

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U.S. Department of Defense (DoD) Assembled Chemical Weapons Assessment (ACWA) Program

- ACWA Program evaluating alternatives to incineration for possible use at several assembled chemical weapons sites
- General Atomics Total Solution (GATS) proposed by GA
  - Two-step process
  - Step 1: Low temperature, low pressure neutralization with caustic
  - Step 2: Supercritical Water Oxidation (SCWO)
- GA selected as one of two technologies for Phase 1 demonstration and follow-on Engineering Design Studies

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Engineering Design Studies (EDS)

- GATS application to two sites being evaluated:
  - Pueblo Chemical Depot, Pueblo, CO
    - Mustard agent (HD, HT) in projectiles and mortars
    - Explosives, dunnage and other wastes
  - Blue Grass Chemical Activity, Lexington, KY
    - Nerve (GB, VX) and mustard (H) agents in projectiles and rockets
    - Explosives, propellants, dunnage and other wastes
- GA is currently carrying out Engineering Design Studies (EDS) at Dugway Proving Ground in Utah
  - Energetics Rotary Hydrolyzer (ERH) (Complete)
  - Dunnage Shredding and Handling System (DSHS) (Complete)
  - SCWO (Fourth 500-hr test in progress)
- Test data utilized for full-scale design packages

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Assembled Chemical Weapons
SCWO Demonstration

Slurry Feed Skid

SCWO Reactor

Reactor Skid

Compressor/Cooling
Tower Skid

Auxiliary Fuel &
Effluent Skid

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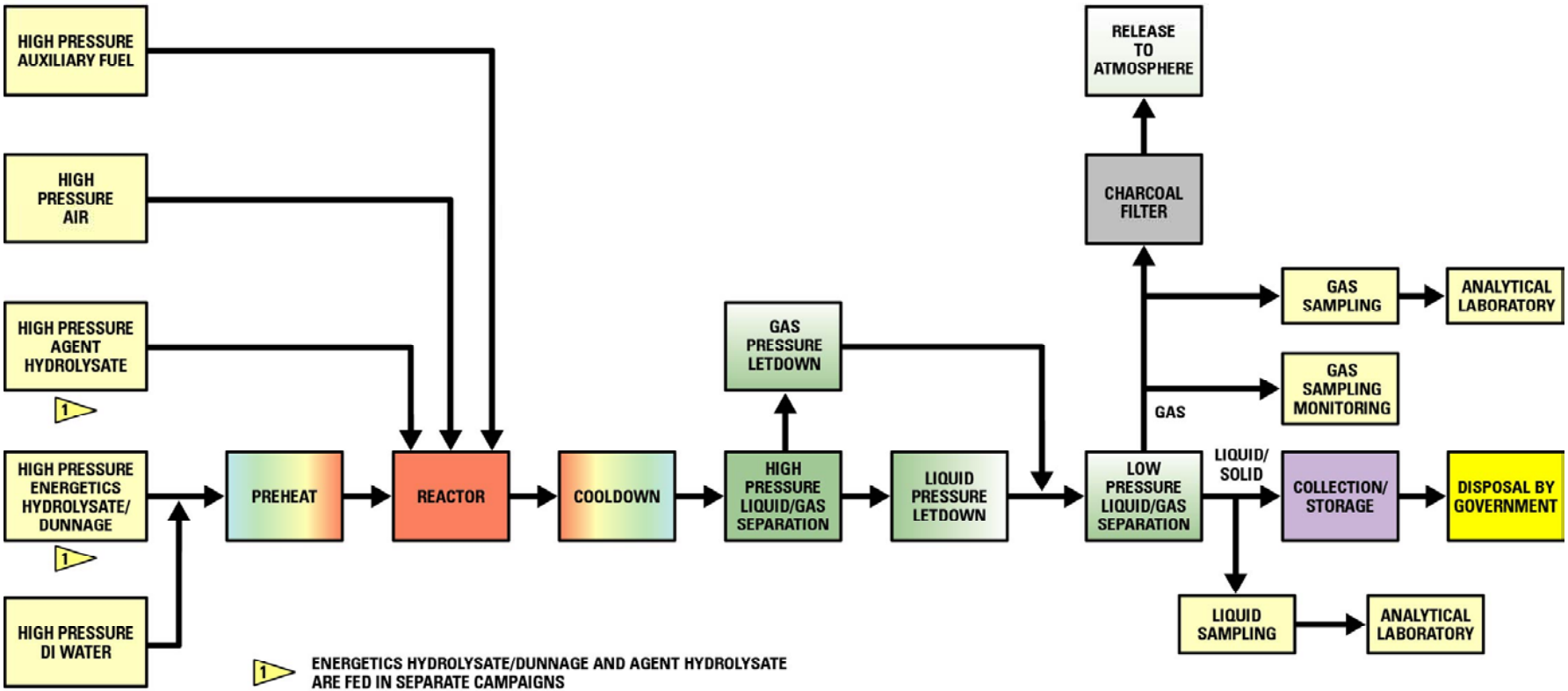
ACWA SCWO SYSTEM BLOCK FLOW DIAGRAM



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500-Hr Tests

- 15% HD hydrolysate or 13% hydrolysate simulant
  - HD is $C_4H_8Cl_2S$, hydrolyzed in water/NaOH
- Tetrytol hydrolysate/dunnage (TD)
  - Tetrytol is CHON, hydrolyzed in NaOH
  - Dunnage is wood, chlorinated plastic, rubber and carbon
  - 9% suspended solids
- M28 hydrolysate/cyclotol hydrolysate/dunnage (MD)
  - M28 and cyclotol are CHON, hydrolyzed in NaOH
  - < 1% suspended solids
- 7% GB hydrolysate or hydrolysate simulant
  - GB is $C_4H_{10}O_2PF$, hydrolyzed in NaOH

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500-Hr Test Operating Parameters

Parameter	HD	TD	MD	GB
Feed lb/hr	63	15	63	63
T, °F	1235	1235	1235	1200
P, psi	3400	3400	3400	3400
τ, sec	15	19	17	17
Salt lb/hr	10	1	13	7

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500-Hr Test Operational Modes

Parameter	HD	TD	MD	GB
Pump type	Double diaphragm	Dual syringe	Dual syringe	Double diaphragm
Liner material	Ti grade 2	Ti grade 2	Ti grade 2	Ti grade 2?
Additive type	Salt transport	Slurry transport	Salt & slurry transport	Salt transport
Rinse cycle, hr	22	22	22	22
Liner replacement or flip, hr	132	None	None*	66?
Thermowell replacement, hr	66	None	None*	None ?
Clean GLS screens, hr	None	44	66	None?

*Changed at 379 hrs due to process upset

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Removable Liner Assembly

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500-Hr Test Operating Statistics

Parameter	HD	TD	MD	GB
Availability	79	79	66	NA
Steady state feed hrs	460	498	497	NA
Availability clock stops	1	1	3	NA
Clock stop reasons	Regulatory/ power failure	Power failure	Memorial Day, 2 power failures	NA

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500-Hr Test Effluent Quality

Parameter	HD	TD	MD	GB
TOC (liquid) ppm	≤ 1.3 ppm	< 1 ppm	≤ 1.9 ppm	Not yet available
TCLP metals (liquid)	Meets criterion except for 5 ppm Cr in feed	Meets criterion	Meets criterion	Not yet available
CO (gas) ppm	< 10	< 10	< 10	Not yet available
NO_x/SO_x (gas) ppm	< 1/< 1	< 1/< 1	< 1/< 1	Not yet available
Dioxins/furans	> 200x lower than EPA MACT standard	Not analyzed	In work	Not yet available

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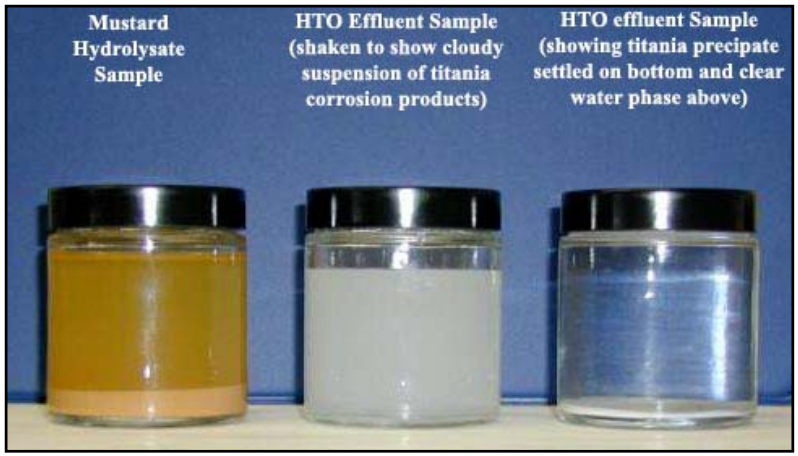
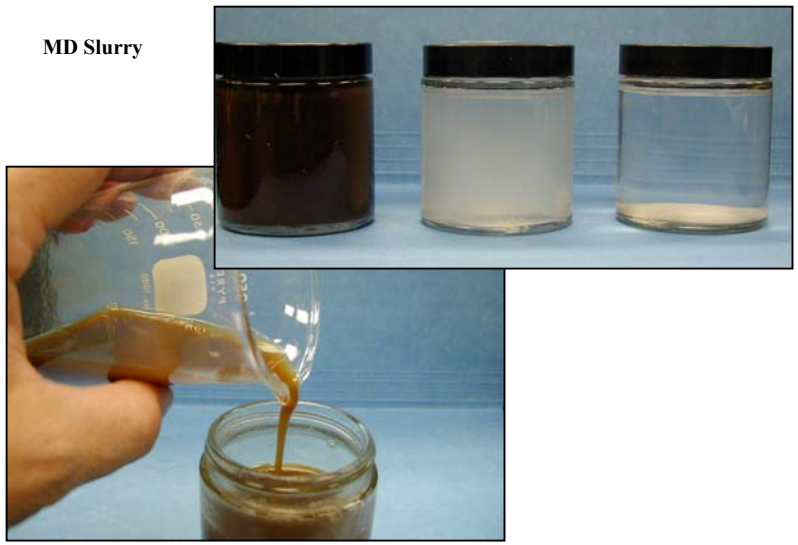
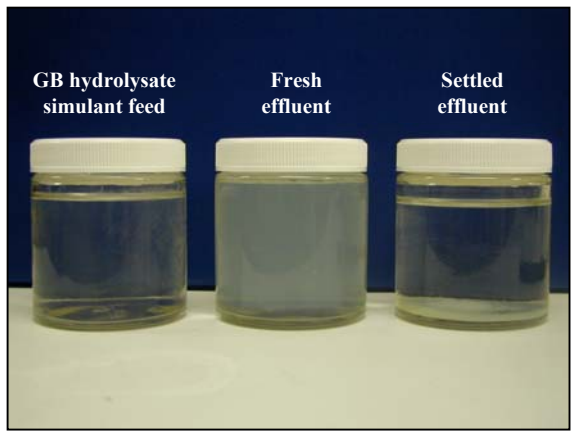
500-Hr Test Feed and Effluent Appearance



MD Slurry





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EDS SCWO Program Totals

as of 8/2/01

Feed Type	Status	Hours Operation
Fuel	Startup/shutdown	713
HD hydrolysate or simulant	500-hr run completed 1/29/01	1172
Tetrytol/dunnage	500-hr run completed 4/14/01	912
M28/dunnage	500-hr run completed 6/29/01	751
GB hydrolysate or simulant	In progress	251
Total		3799

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Conclusions For EDS Testing

- SCWO system readily supports required whole-plant availability of 39%
- Readily available, inexpensive titanium grade 2 is a suitable liner
- Salt flush required not more than once a day
- System pressure and temperature control are well-maintained
- Outstanding effluent quality is achieved
- System is robust and safe

500-Hr Test Challenges

- HD
  - Corrosivity towards platinum
- TD
  - SCWO of activated carbon
- MD
  - Insoluble salts
- GB
  - Corrosivity towards titanium

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Full-Scale Design Features

- Whole-plant availability of 39%
- Multiple (4) SCWO trains
- Air oxidant
- Reactor design
  - Removable liner replaced after 1 week or longer
  - 18.4” ID by 221” IL (~ 100x larger volume than EDS)
  - Scale up based on NECDF (~ 4x scaleup)
  - Total throughput 22,000 lb/hr
- Redundant key equipment e.g. pumps, on each train
- Brine evaporation and water recycle

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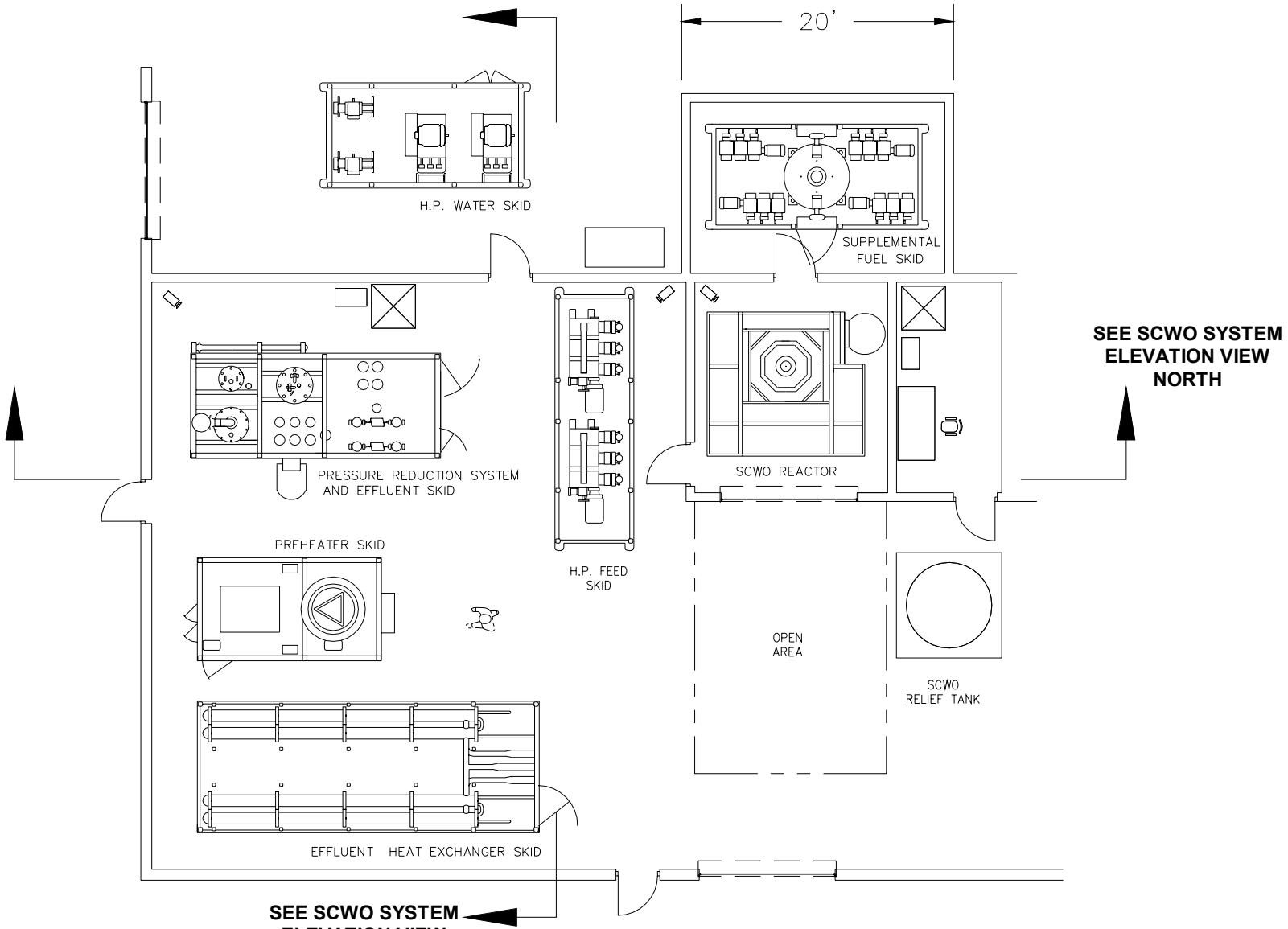
SCWO REACTOR SYSTEM - PLAN VIEW



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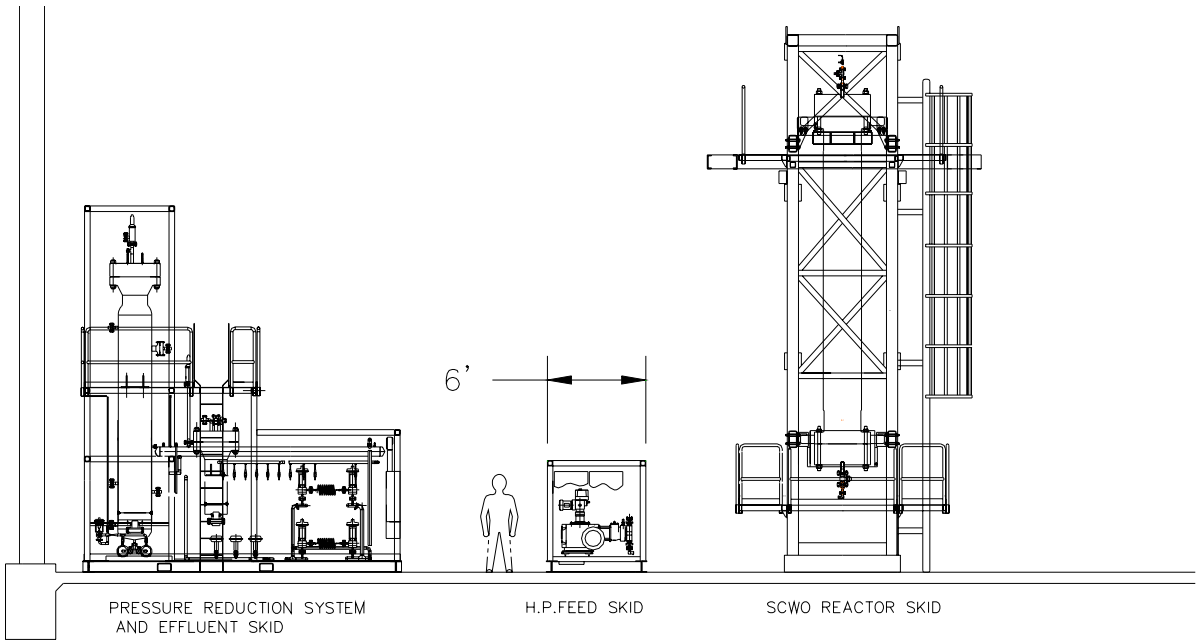
SCWO SYSTEM ELEVATION VIEW (NORTH)



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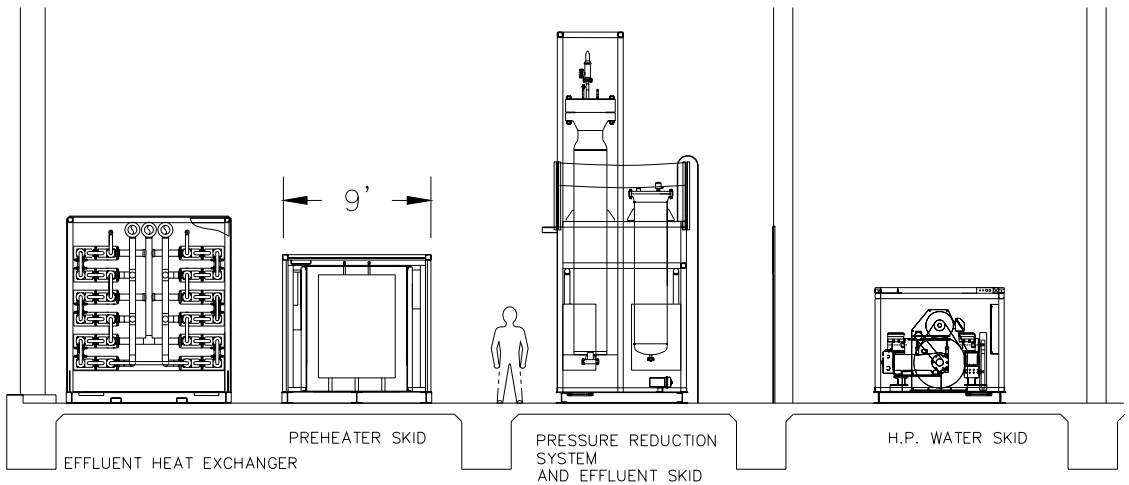
SCWO SYSTEM ELEVATION VIEW (WEST)



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